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(54) Improvements in and relating to respirators.

(57) The present invention relates to improvements in power assisted positive pressure respirators for use in contaminated atmospheres.

The respirator comprises a facepiece 1 having an inlet 3 connected to a pump unit 5 for supplying air to the facepiece which has been filtered by filter means 11 connected to the pump unit inlet. The facepiece is also provided with an outlet provided with a one-way valve 2 which is biased to its closed position and is openable when a predetermined pressure above atmospheric pressure is established within the facepiece.

To maximise use of the filter means 11, a one-way inlet valve 13 is provided intermediate the pump unit 5 and the facepiece 1, conveniently at the inlet to the facepiece, which is closed during exhalation by the wearer to thereby cause the pump to be placed in a condition in which, although it continues to operate, no or substantially no air is moved thereby, so that during this period, no or substantially no air is drawn through the filter means 11.

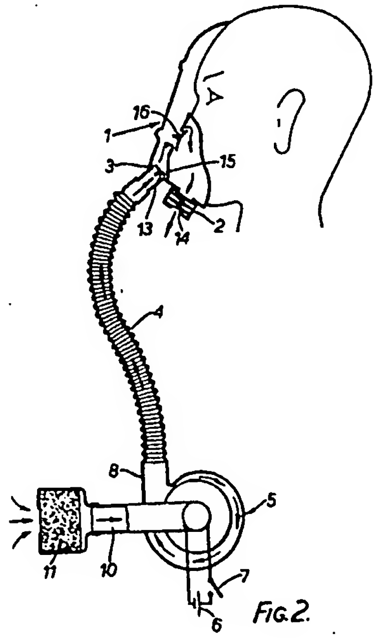

FIG.2.

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Improvements in and relating to Respirators

The present invention relates to improvements in respirators for use in contaminated atmospheres.

Power assisted respirators for use in dusty atmospheres are known. Such respirators normally include a pump which supplies filtered air from the atmosphere to a facepiece covering at least the nose and mouth of the wearer. The facepiece generally includes a one-way outlet valve which is operative to maintain under normal conditions a slight positive pressure within the facepiece, for example according to British standard 4558 a pressure of 125 pascals at 85 litres/minute. The pump is arranged to supply air to the facepiece at a constant rate, for example about 120 litres per minute, which is greatly in excess of the average inspiratory requirements of the wearer. U.K. and European standards require a minimum flow of 120 litres per minute for four hours in order to sustain a degree of positive pressure within the mask even at typical peak inhalation rates. In the U.S.A. the relevant standard requires a minimum flow of 113 litres per minute for tight fitting full face masks and 170 litres per minute for helmets and hoods.

Because excess filtered air is constantly supplied to the facepiece, the filters are used up much faster than they need to be and indeed only about one third of the capacity of a filter is effectively used for filtering air which is breathed.

Dust and other particulate material filters have a relatively long life and such inefficient use can be tolerated. However gas and vapour filters, usually in the form of canisters containing granulated activated charcoal, silica gel, molecular sieve material or similar materials, have a much shorter life such that their use in power assisted respirators has not to date been considered practical. As a consequence most gas and vapour filtering respirators are unpowered, the wearer drawing air into the facepiece through the filter using the power of his lungs.

According to one aspect of the present invention there is provided a power assisted respirator comprising a facepiece for covering at least the mouth of the wearer and having an inlet and an outlet, one-way valve means in the outlet which is openable during exhalation by the wearer to permit air to flow out of the facepiece when a predetermined differential pressure is established thereacross, pump means connected to th inlet for supplying air to the facepiece, and filter means for filtering air supplied by the pump means to the facepiece, characterised in that a one-way valve is provided in the path of air flowing from the pump means to the facepiece, which valve means is arranged to be closed during exhalation by the wearer when the pressure downstream thereof exceeds that upstream thereof and so that the pump means will thereby be placed in a condition such that, although the pump means continues to operate, little or substantially no air is driven thereby.

According to another aspect of the present invention there is provided a method of operating a power

assisted respirator comprising a facepiece for covering at least the mouth of the wearer and having an inlet and an outlet, one-way valve means in the outlet which is openable to permit air to flow out of the facepiece, pump means connected to the inlet for supplying air to the facepiece , and filter means for filtering air supplied by the pump means to the facepiece, the method comprising providing a one-way valve means in the path of air flowing from the pump means to the facepiece and causing the one-way valve means to be closed during exhalation by the wearer so as to place the pump means in a condition such that, although it continues to operate, little or substantially no air is driven thereby.

In a preferred embodiment, the outlet valve is arranged to open when the pressure within the facepiece exceeds about 600 pascals, e.g. as set out in British standard 4667 Part 2 relating to respirators using bottled gas (rather than the much lower operating pressures normally required for power assisted positive pressure respirators). Additionally in this preferred embodiment the pump is arranged to cease or substantially cease pumping effectively when the pressure downstream of the pump and upstream of the inlet valve is about 600 pascals.

The pump may optionally be arranged to provide a maximum of about 200 litres per minute and a minimum of 0 litres per minute, depending on demand and the resistance to flow presented by the filter means.

It has been found that in use of such a system, the proportion of the filter means which is effectively used for filtering air which is then breathed can be increased from one third to at least 80%.

The facepiece may be a partial or full face mask, or may be in the form of a helmet or hood if adequately sealed to the head, which may be connected by a flexible hose to a unit including the pump and filter means.

Advantageously the filter means comprise one or more cartridges or canisters of filter material which are removably mounted on the inlet to the pump. The pump preferably comprises a fan driven by a motor which is battery operated so that the assembly is portable.

An embodiment according to the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of an embodiment of respirator in use;

Figure 2 is a diagrammatic view of the respirator of Figure 1;

Figures 3 and 4 are perspective views with parts broken away showing the inlet and outlet to the facepiece and the pump unit respectively; and

Figure 5 is a schematic drawing showing operation of components of the respirator in relation to the respiratory cycle of the wearer.

The respirator shown in Figures 1 and 2 comprises a facepiece 1 which, as shown, is a full face mask covering the eyes, nose and mouth of the wearer, and which is peripherally sealed to the head of the wearer. The facepiece 1 is provided with an outlet provided with a one-way outlet or exhalation valve 2 through which air leaves the mask, and an inlet 3 which is connected by a flexible hose 4 to a unit 5. The unit 5 is, as shown, supported by a harness on the back of the wearer but may alternatively be mounted by a similar harness on the front of the wearer. The unit 5 comprises a housing in which a pump unit comprising a fan, for example a centrifugal fan, and a battery operated motor are housed. The housing has an outlet 8 defining the outlet of the fan and to which the hose 4 is connected, and one or a plurality of, e.g. as shown three, inlets 10 connected to the fan inlet. Each of the housing inlets 10 is threaded to receive a filter cartridge or canister 11, which may comprise a particulate filter material

and/or a gas or vapour filter material. One such cartridge or canister 11 may be mounted on the or each or some of the inlets 10 and any unused inlets may be closed by a plug 12.

It will be appreciated that by increasing the number of cartridges or canisters 11 provided the rate of flow of air through each cartridge or canister can be reduced, thereby increasing the efficiency of filtering and reducing the resistance to flow of air through the respirator. The motor is connected, as shown, by a cable 27 to a separate unit comprising a battery 6 and optionally an off/on switch 7 controlling power supplied to the motor. Alternatively the battery and, where provided, the switch may be mounted within the unit 5.

As shown in Figure 2, the outlet valve 2 is biased to its closed position, for example by a helical spring 14, and so that the valve will only open to permit air to flow out of the facepiece when the air within the facepiece is at a preset pressure above atmospheric pressure, for example so that the valve will open when the pressure within the facepiece is about 600 pascals.

A one-way inlet valve 13 is mounted in the inlet 3 of the facepiece and is openable to permit air to flow from the pump to the facepiece. The valve 13 may, for example, be a flap valve and is unbiased so that the valve will close as soon as the pressure downstream thereof within the facepiece exceeds that upstream thereof within the hose 4.

The rate and throughput of the pump unit 5 are selected so that, during exhalation by the wearer, the pressure within the facepiece will build up to a point where it exceeds that in hose 4. At this point, the valve 13 will close. Closure of valve 13

causes an immediate build-up of pressure within hose 4 and this build-up of pressure is arranged so that the pump unit 5 will be placed in a condition in which, although it continues to operate, it ceases or substantially ceases to drive air into the system and therefore to draw air through the filters. Additionally, during exhalation, valve 2 will open to permit exhaled air to flow out of the facepiece and this may take place at about the same time as closure of valve 13.

Towards the end of exhalation, the pressure within the facepiece will fall causing valve 2 to close and causing valve 13 to open, when the pressure falls below that in hose 4. At this point the pump will start to operate effectively again to supply to the facepiece the air required for inhalation.

Thus by suitable selection of the operating pressure of the outlet valve 2 in relation to exhalation pressure and the pump characteristics, the effective operation of the pump can be made to vary with the breathing cycle of the wearer. This then reduces the amount of air which is drawn into the facepiece through the filters and which is not then breathed so that a point can be reached where at least 80% of the life of the filters is used for filtering air which is then inhaled.

Figure 5 shows schematically the presently preferred operation of the pump unit 5 and inlet and outlet valves 12 and 2 in relation to the respiratory cycle of the wearer. As shown valves 13 and 2 open and close at about the same points in the respiratory cycle, although these points may be relatively displaced.

As shown, the facepiece includes an inner mask 15 which closely surrounds the nose and mouth of the wearer and is provided with one or more one-way inlet valves 16. These valves may for example be flap valves which are unbiased and serve to prevent flow of exhaled air into the

total volume of the facepiece so as to limit the amount of exhaled air which may be re-breathed. However, if the inner mask is sufficiently well sealed to the wearer's face to prevent leakage around the edges, valve 13 may be omitted, the or each valve 16 performing its function.

Figures 3 and 4 show preferred embodiments of the valves 2, 13 and the pump unit 5. As shown in Figure 3, the valve 13 is a flap valve comprising a flexible disc 20 which is seated over a seat 21 surrounding an opening in the passage of inlet 3 to the facepiece, and lifts from seat 21 to allow air to flow into the facepiece when the pressure in the facepiece is lower than that in the hose 4. The outlet valve 2 comprises a flap valve comprising a rigid disc 22 which seats against an outlet seat 23 surrounding an outlet opening and is biased to its closed position by helical spring 14 which bears against the disc 22 and a part of the housing around the outlet. Air exits from the valve through openings 24 communicating with the opening in seat 23.

The pump unit 5 shown in Figure 4 comprises a motor 26 connected by cable 27 to the battery and to the shaft 28 of a centrifugal fan 29 whose outlet is connected to outlet 8 provided by the unit housing. The fan inlet is connected, as shown, to three inlets 10 provided by the housing, each of which is threaded to receive a filter canister or cartridge 11. One, two or three cartridges or canisters may be used and any unused inlets may be closed by a plug 12.

In a preferred embodiment of the above described respirator, the outlet valve 2 is arranged, as previously mentioned, to open when the pressure in the facepiece is about 600 pascals. The inlet valve 13 closes as soon as the pressure within the facepiece exceeds that within the hose 4, which is generally when the pressure within the facepiece is about 600 pascals, and the fan 29 is arranged

to provide up to about 200 litres per minute depending on demand. At the point at which valve 13 closes, the pressure in the hose 4 will be about 600 pascals but just below the pressure in the facepiece, and at these pressures, the fan will then be placed in a condition in which, although it continues to rotate, no or substantially no air flows therethrough and specifically no air is drawn thereby into the unit housing and through the filter cartirdges or canisters.

It will be appreciated that the above pressures and flow rates are exemplary only and that they may be higher or lower depending on the particular requirements for the facepiece.

It will also be appreciated that, while the invention has been described above in terms of a respirator comprising a full face mask, it is equally applicable to partial face masks and to facepieces in the form of hood or helmets which are adequately sealed to the head of the wearer. Additionally, while in the above described respirator, the valve 13 is placed in the inlet to the facepiece, this valve may be provided at any convenient point intermediate the fan and the facepiece. It will further be appreciated that, although the above described respirator has particular application to gas and vapour filtering, it is of course equally applicable to dust or particulate material filtering because an increase in the efficiency of use of any such filter is beneficial.

CLAIMS:

1. A power assisted respirator comprising a facepiece 1 for covering at least the mouth of the wearer and having an inlet 3 and an outlet, first one-way valve means 2 in the outlet which is openable during exhalation by the wearer to permit air to flow out of the facepiece when a predetermined differential pressure is established thereacross, pump means 5 connected to the inlet 3 for supplying air to the facepiece, and filter means 11 for filtering air supplied by the pump means to the facepiece, characterised in that second one-way valve means 13 is provided in the path of air flowing from the pump means to the facepiece, which valve means 13 is arranged to be closed during exhalation by the wearer when the pressure downstream thereof exceeds that upstream thereof and so that the pump means will thereby be placed in a condition such that, although the pump means continues to operate, little or substantially no air is driven thereby.

2. A respirator as claimed in claim 1, characterised in that the second one-way valve means 13 is mounted in the inlet 3 of the facepiece.

3. A respirator as claimed in claim 1, characterised in that the second one-way valve means 13 is mounted intermediate the outlet of the pump means 5 and the inlet 3 of the facepiece.

4. A respirator as claimed in any one of the preceding claims, characterised in that the second one-way valve means 13 comprises a flap valve which is unbiased so as to close as soon as the pressure

downstream thereof exceeds that upstream thereof.

5. A respirator as claimed in any one of the preceding claims, characterised in that the first one-way valve means 2 is a flap valve which is biased to its closed position.

6. A respirator as claimed in any one of the preceding claims, characterised in that the pump means 5 is connected to the facepiece by a flexible hose 4 and is adapted to be carried by the wearer.

7. A respirator as claimed in any one of the preceding claims, wherein the facepiece 1 covers the mouth and nose of the wearer.

8. A respirator as claimed in any one of the preceding claims, wherein the facepiece 1 covers the mouth, nose and eyes of the wearer.

9. A method of operating a power assisted respirator comprising a facepiece 1 for covering at least the mouth of the wearer and having an inlet 3 and an outlet, first one-way valve means 2 in the outlet which is openable to permit air to flow out of the facepiece, pump means 5 connected to the inlet 3 for supplying air to the facepiece 1, and filter means 11 for filtering air supplied by the pump means 5 to the facepiece, the method comprising providing a second one-way valve means 13 in the path of air flowing from the pump means 5 to the facepiece and causing the second one-way valve means 13 to be closed during exhalation by the wearer so as to place the pump means 5 in a condition such that, although it continues to operate, little or substantially no air is driven thereby.

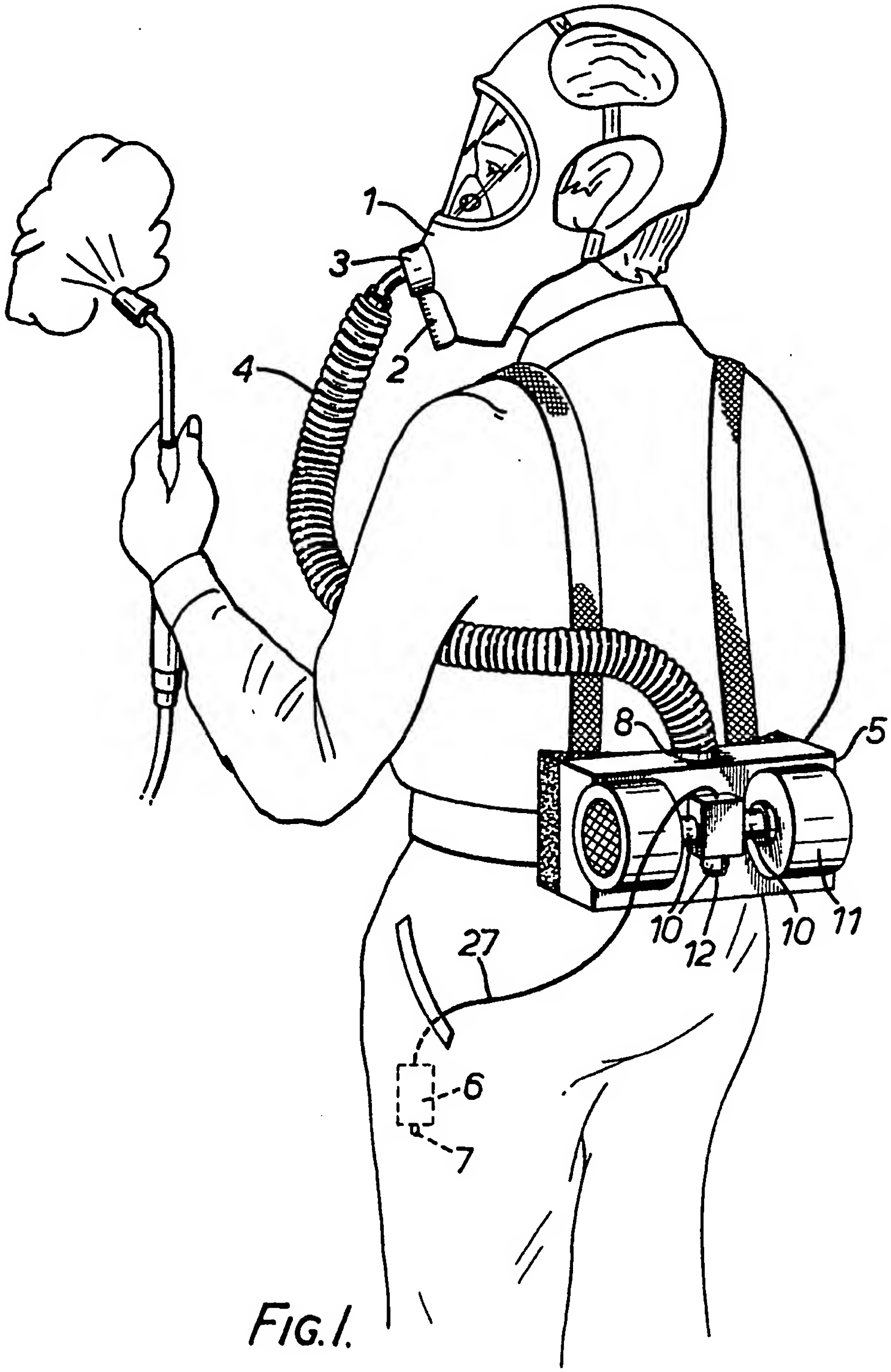

FIG. 1.

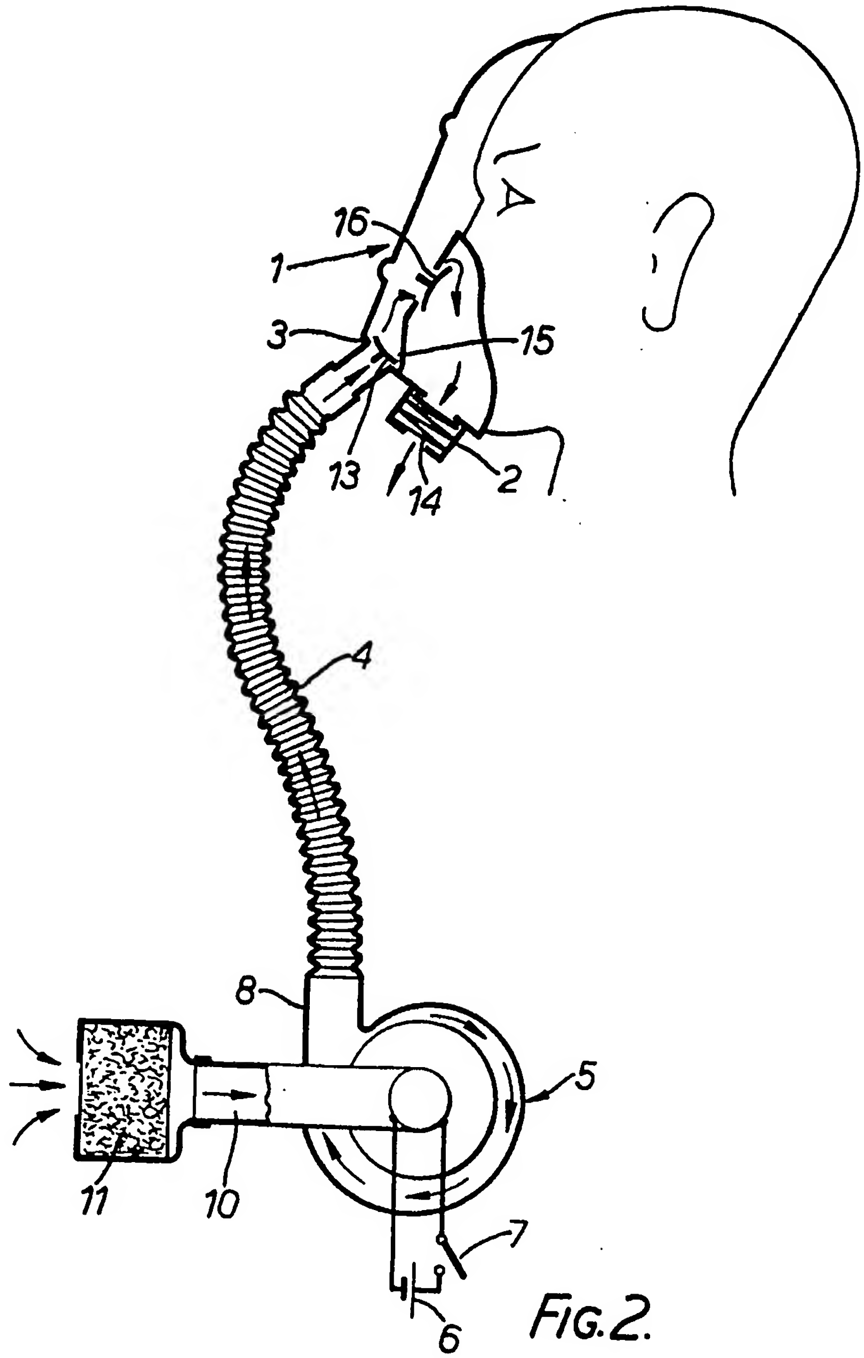

FIG. 2.

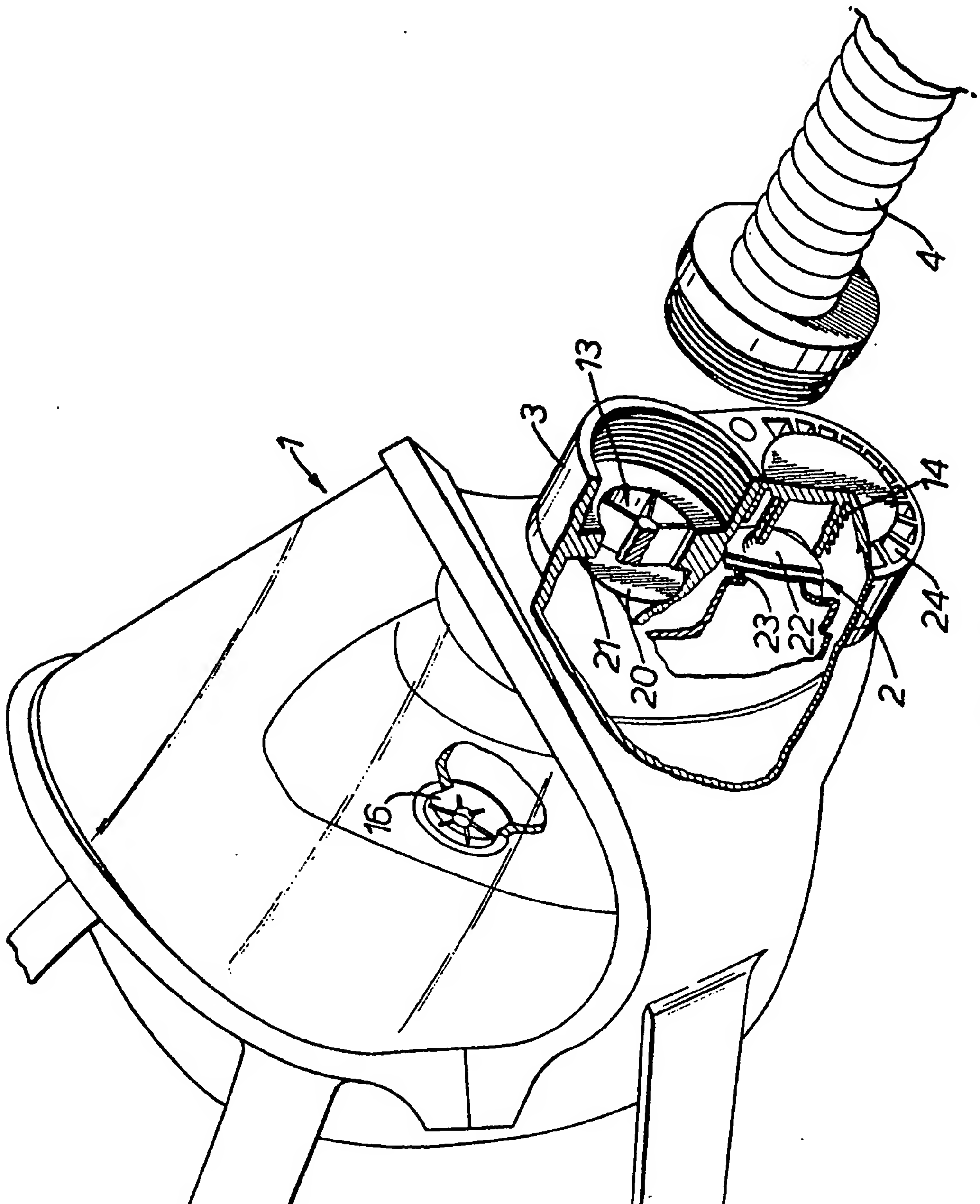

FIG. 3.

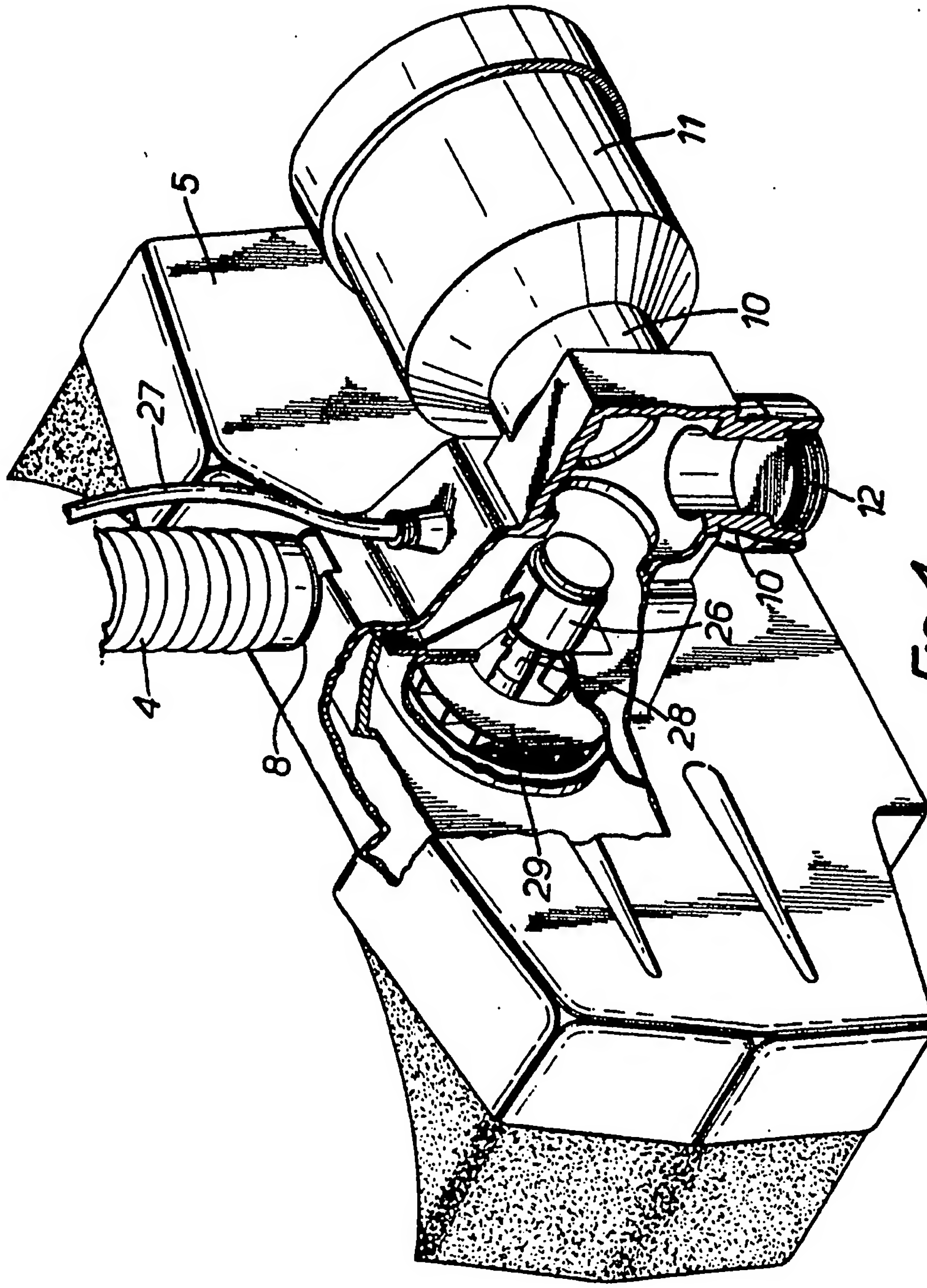

FIG. 4.

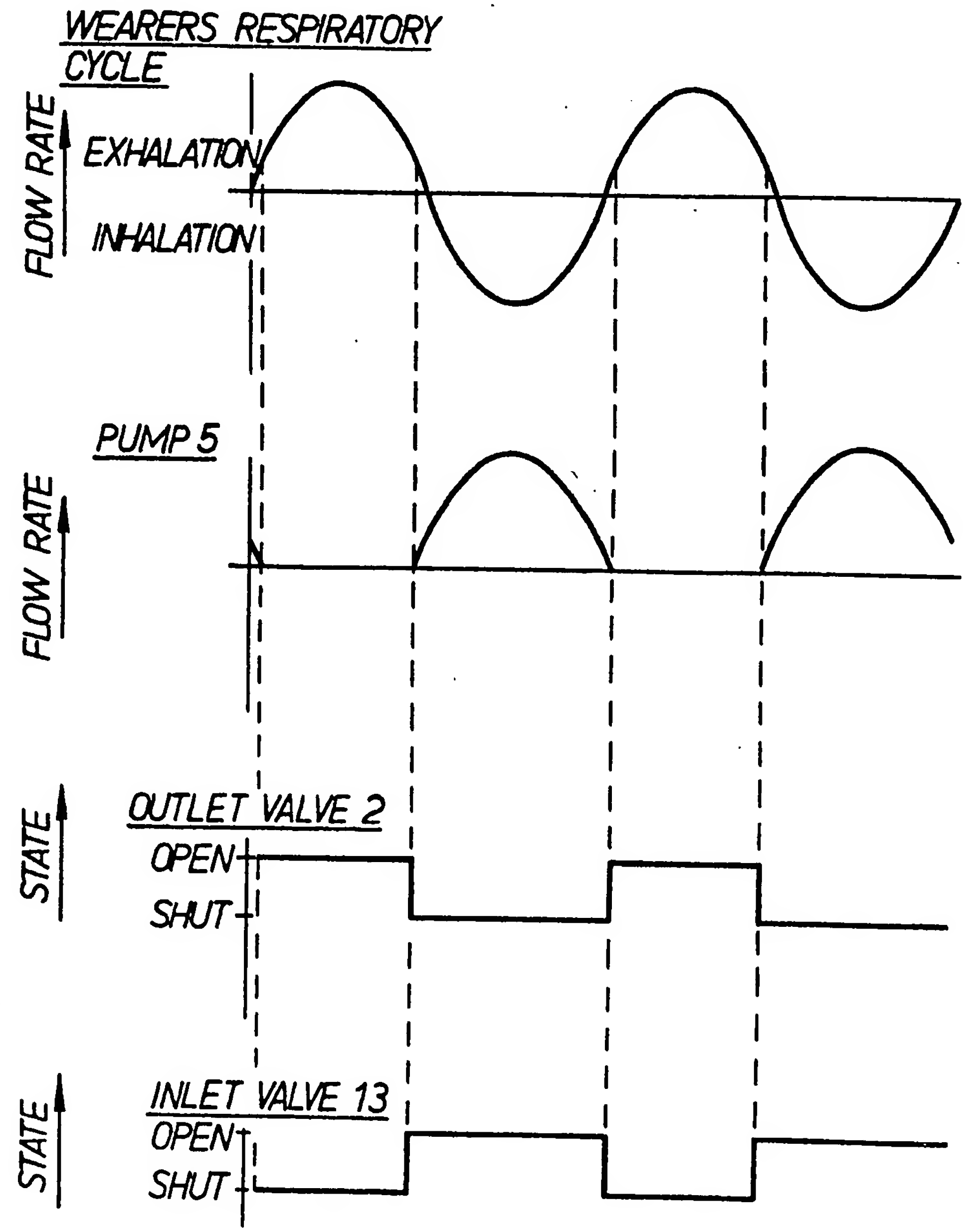
WEARERS RESPIRATORY CYCLE
FLOW RATE
EXHALATION
INHALATION
PUMP 5
FLOW RATE
OUTLET VALVE 2
STATE
OPEN
SHUT
INLET VALVE 13
STATE
OPEN
SHUT

FIG. 5.